DIMI-6000: An Early Musical Microcomputer by Erkki Kurenniemi

Kai Lassfolk
Musicology
Department of Philosophy, History, Culture and Art Studies
University of Helsinki
kai.lassfolk@helsinki.fi

Jari Suominen
Tasankokaiku Productions
Turku, Finland
jari.suominen@tasankokaiku.com

Mikko Ojanen
Musicology
Department of Philosophy, History, Culture and Art Studies
University of Helsinki
mikko.ojanen@helsinki.fi

ABSTRACT

The DIMI-6000 is an early microcomputer-based synthesizer designed in the mid-1970s by the Finnish inventor Erkki Kurenniemi. Designed as a hub for electronic music studios, the DIMI-6000 featured computer-controlled analog sound synthesis circuitry and a modular design. Despite its innovative design, only two units were built, one for Finland's national broadcasting company YLE and the other for Swedish composer Ralph Lundsten. This paper presents an overview of the instrument and its use, especially of the unit built for YLE's Experimental Studio.

1. INTRODUCTION

In the 1960s and 1970s Kurenniemi made a significant contribution to the early development of Finnish electroacoustic music. Kurenniemi played a multi-faceted role as a studio builder, composer and especially as a designer of electronic instruments. From the early 1960s to the mid-1970s, he designed ten unique musical instruments and studio devices for various studios, composers and artists in both Finland and Sweden. After a series of custom-built one-off devices, Kurenniemi founded the Digelius Electronics Finland company for manufacturing and marketing the DIMI line of instruments. However, none of the instruments were developed beyond the prototype stage and their serial production was never begun. As a result, most of the remaining instruments are unique. Nevertheless, Kurenniemi's instruments and their sound are a distinctive feature of early electronic music in Finland. Their sound also made its mark on Swedish electronic music through the works of composer Ralph Lundsten. An overview of Kurenniemi's instruments is presented by Ojanen et al. [1].

The microprocessor-controlled synthesizer DIMI-6000 was the last of Digelius Electronics' musical instruments. The DIMI-6000 was commissioned by YLE for its newly-founded Experimental Studio. Composer Henrik Otto Donner, the head YLE's music entertainment department at the time and Kurenniemi's close collaborator from the early 1960s, organized the funding for the purchase of the instrument and user training. DIMI's Finnish design and manufacture was considered an asset and Donner and the Experimental Studio team saw the project partly as an opportunity to promote national expertise in modern technology. A second unit was built for Lundsten's Stockholm-based Andromeda studio.

The DIMI-6000 was Kurenniemi's most ambitious instrument. In contrast with some of Kurenniemi's previous designs, it was more than a mere case study of musical user interfaces or application of digital electronics. Instead, it introduced many features of the computer-based synthesizers of the 1980s and even of modern digital audio workstations. In contrast to typical mainframe-computer-based hybrid systems of the early 1970s, the DIMI-6000 was a compact device and relatively easy to transport.

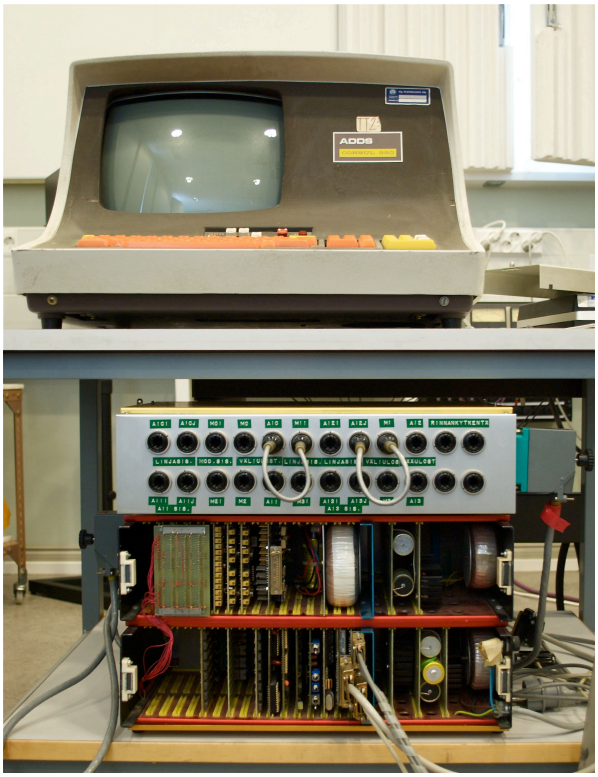

Figure 1. The YLE DIMI-6000 system at the University of Helsinki Electronic Music Studio in 2014. (Photo: Kai Lassfolk.)

Copyright: © 2014 Kai Lassfolk, Jari Suominen and Mikko Ojanen. This is an open-access article distributed under the terms of the Creative Commons Attribution License 3.0 Unported, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

The DIMI-6000 was in use at YLE until the late 1980s and was put in storage for most of the 1990s. In 2002, the YLE unit was given to the University of Helsinki Electronic Music Studio where it remains on display along with most of Kurenniemi's other instruments (see Figure 1). Lundsten's DIMI-6000 saw little use; soon after its purchase, part of the hardware was dismantled or lost. However, the sound generator unit remained in Andromeda until 2014, when he donated all of the studio's equipment to the Swedish Museum of Performing Arts in Stockholm. One of the first microcomputer-based musical instruments in the world, the DIMI-6000 represented a significant technical advancement in Finland at a time when even analog synthesizers were uncommon in the country.

2. EARLY DESIGN IDEAS

Kurenniemi's working style has often been described as impulsive. Indeed, many of his instruments remained in the prototype stage as he had already started working on the next one. Even the DIMI-6000, the most advanced of his projects in many ways, can be regarded as a prototype when considered as an individual instrument. However, when Kurenniemi's instrument design work is viewed as a whole, it forms a logical process that points directly towards modern music production methods and computer-based modular digital audio workstations. In this process, the DIMI-6000 is an important step.

In the 1960s Kurenniemi was already well known among the Finnish electroacoustic music community for his advanced instrument designs. An amateur radio operator in his teens, Kurenniemi acquired strong experience with electronics very early on. With his schoolmates Erkki Salmenhaara and Ilkka Oramo, both future professors and musicologists, Kurenniemi built a modest electronic music studio in the organ balcony of his school in the late 1950s. Some years later the newly appointed professor of musicology, Erik Tawaststjerna, was looking for someone to build an electronic music studio on the premises of the Department of Musicology at the University of Helsinki. During the 1960s, Kurenniemi was free to design instruments according to his vision. He received no salary, but the department provided funding for the studio equipment and component purchases.

Kurenniemi's studio and instrument design plans during the 1960s and early 1970s exhibit two primary trends. Firstly, he was interested in algorithmic composition and in designing an instrument that could produce pre-programmed music with "a flick of a switch". The application of digital logic to sound production and control became important to Kurenniemi. Among his sources of inspiration were the RCA synthesizer of the 1950s by Olson and Belar [2] as well as his programming experience with the analog computer of the University of Helsinki's Department of Nuclear Physics in the early 1960s. Kurenniemi was convinced that "the future will be digital" [3] and chose to design his studio based on digital logic - a trend which had already been applied in the Siemens studio in Munich as well as a couple of years later in Stockholm at EMS.

Secondly, in his early studio design Kurenniemi already envisioned the studio as an integrated system of modules for sound production and processing. The first version of this idea was his three-piece studio device initially called the Sähkö-Ääni-Kone (Electric Sound Machine). Later in Kurenniemi's memos this integrated set of equipment is called System-1, and years later it was retitled Integrated Synthesizer. In the 1970s, this design trend appeared in Kurenniemi's work as the modular DIMI-U (U for Universal) system. The DIMI-U was based on an idea that the customer could choose from a set of different sound producing and processing modules. No DIMI-U systems were built, but the microcomputer-controlled DIMI-6000 can be seen as one manifestation of the basic idea and anticipated a computer-based music production suite.

Until the early 1970s, the University of Helsinki Electronic Music Studio was the best equipped of its kind in Finland. In contrast, the equipment of the YLE Experimental Studio, founded in 1973, was initially modest, consisting of a couple of tape recorders and sound generators. The DIMI-6000 was thus a major endeavor for YLE. At Donner's request, Kurenniemi presented his ideas for the possible features of the new instrument at YLE. The first steps in designing the instrument were made in 1974 [4]. Although YLE's main objective was to acquire an advanced synthesizer, one of the initial ideas was also to replace the studio mixer, an expensive device at the time [5].

Kurenniemi's earlier instrument, the DIMI-A was used as a starting point, although aiming for a much more advanced design. Instead of the discrete digital logic circuitry and shift register memory of the DIMI-A, a modern microprocessor chip and random access memory were chosen for the DIMI-6000. Moreover, the DIMI-A was severely limited by its small parameter memory and lack of mass storage device. Ideas from analog synthesizers, such as the VCS-3 synthesizer of the University studio, were also adapted. As a result, the DIMI-6000 became a microcomputer-controlled analog synthesizer with a semi-modular architecture. In April 1975, the instrument was delivered to the YLE studio followed by a one month course of user training by Digelius and Kurenniemi [4].

3. HARDWARE ARCHITECTURE

The DIMI-6000 hardware consists of a main chassis, a video computer terminal and one or two cassette mass storage devices. Both the terminal and cassette units are general purpose devices. The terminal is an ADDS Consul 880 and the cassette units were ITT SL 56 Automatic models which were standard reporter tape recorders at YLE. The main chassis was manufactured by Digelius Electronics.

The main chassis of the YLE's DIMI-6000 consists of three parts: processor unit, (sound) generator unit and patch bay. The physical patch bay was added by special request from YLE. The processor unit of the DIMI-6000

was based on the Digelius Electronics DIS System, the first microcomputer manufactured in Finland. Like the DIS System, the control unit is based on the Intel C8008 8-bit microprocessor. The random access memory was expanded in several stages. Initially, the instrument had 4 kilobytes of RAM [4]; later this was expanded to 7 kilobytes, and a further expansion of 4 KB was planned [6]. 1.25 KB of the processor memory map was allocated for ROM and the remaining memory was left for the system software and user programs.

The generator unit contains four oscillators, four multiplier modulators, two filters and two main audio outputs. The oscillators have separate outputs for sine, triangle and square waveforms. Kurenniemi considered 8-bit digital oscillators for the DIMI-6000, but, interestingly, did not find the sound quality sufficient for this application [7]. Instead, he used ICL8038 waveform generator chips which had been introduced a few years earlier and would later end up being one of the most popular microchips for such purposes [8]. The multiplier units are based on the ICL8013 chip and may be used either as ring modulators or voltage controlled amplifiers, depending on the input signals. The filters have dedicated low-pass, band-pass, and high-pass outputs [9]. Both the processor and generator units contain standard-size interchangeable PCB cards based on the Eurocard system.

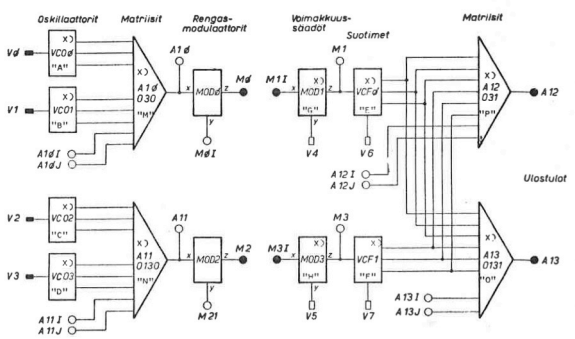

Figure 2: Block diagram of the DIMI-6000 signal path [6]

The signal path is divided into two parallel halves each with two oscillators, a ring modulator, an amplifier and a filter. (See Figure 2.) Each oscillator pair is followed by an 8-input/1-output switching matrix that makes it possible to mix the oscillator waveforms and two external input signals. Another pair of switching matrices is located between the filters and main audio outputs. Each of these matrices allows for the mixing of the outputs of the three filter bands of both of the two filters and the two external input signals. The oscillators, amplifiers and filters are voltage-controlled with 10 bit resolution while the semiconductor switching matrices are controlled by digital on/off signals.

The audio inputs and outputs as well as various signal insert and input/output connectors are located in the Tuchel connector based patch bay unit. Furthermore, each of the parallel signal paths is split into two sections in between the ring modulator and amplifier. The matrices and the physical patch bay provide a two-level modular architecture for the generator unit. Installed as a late addition, the patch bay unit includes D-connectors for 8 digital-to-analog and 16 analog-to-digital converter signals.

The cassette players act both as mass storage devices and as recording and reproduction devices for real-time digital control commands. Typically, one cassette player was used to play back previously recorded control data and the other one was used for simultaneous recording. This allowed for real-time overdub recording of the control data. The ADDS terminal provides the main user interface of the system through its computer keyboard and ASCII character output.

4. USER INTERFACE AND SOFTWARE

The first system software of the DIMI-6000 was DISCORD, written by Kurenniemi. DISCORD was a simple program that made it possible to play the instrument [10]. DISCORD allowed for the programming of timed sequences as well as real-time control from the terminal keyboard. Only miscellaneous handwritten notes remain from the DISCORD documentation.

Based on user experiences with DISCORD, composer and programmer Jukka Ruohomäki was hired to develop new software both to address the instrument's technical shortcomings and to enhance its user interface. In 1977, he completed the DISMAL (DIS Musical Assembly Language) program. In particular, DISMAL addressed the problems of tuning the unstable oscillators through tuning tables. Ruohomäki also wrote a detailed operating manual for DISMAL and the overall use of the instrument.

Like DISCORD, DISMAL allowed for both real-time playing and the writing of pre-programmed sequences called ‘scores’. In practice, the DIMI-6000 was typically used by typing the 8008 processor instructions as octal codes which, according to Ruohomäki [10], were easy to memorize.

The DISMAL user manual [6] points out several shortcomings and peculiarities of the instrument. The 8008 processor was already considered outdated and too slow for advanced use. Furthermore, the control voltage values of the DACs had to be refreshed periodically by the user, which added to the processing overhead of the system. The boot procedure of the instrument was cumbersome and could require several attempts to get it into a stable state. The DISMAL system worked as a program interpreter rather than a compiler, with obvious penalties to the program execution speed.

After the completion of DISMAL version 1.0, a 16 channel AD converter was added to the main chassis. Ruohomäki was once again contracted to write the sequencer program, DISEQ, to take advantage of the new hardware. However, both DISMAL and DISEQ saw little

or no use other than Ruohomäki himself. DISEQ was neither fully completed nor documented [10].

5. USE IN THE YLE EXPERIMENTAL STUDIO

The DIMI-6000's users included composers Pekka Sirén, Otto Romanowski, Joe Davidow, Jukka Ruohomäki and Marja Vesterinen. Ruohomäki, for example, used the instrument to make sound material for his composition *Ennen iltaa* (*Late Afternoon* 1977). Sirén, a full-time sound engineer and one of the main forces at the Experimental Studio, was the most active user and advocate of the instrument. Sirén made several compositions and miscellaneous recordings with it. He also assisted and instructed many of the other users. The DIMI was also used to make sound effects for various YLE programs. However, overall usage of the instrument was limited.

According to Sirén [5], the DIMI-6000 served best as a chaotic sound generator. It produced a raw and rough sound and was capable of producing more complex sound gestures than, for example, the Minimoog. On the other hand, many "keyboard-oriented" composers were deterred by the computer terminal user interface. As a result, it did not fulfill all the initial expectations. Instead of substituting for a mixer and serving as the central hub of the studio, the DIMI-6000 was used as a special purpose instrument among the other studio devices. Gradually, as the studio acquired new equipment, the role of the DIMI-6000 diminished even further. Most notably, the acquisition of a PDP-11 minicomputer and the Synclavier programmable synthesizer made the DIMI-6000 practically obsolete.

In the 1990s, the instrument lay abandoned in storage at YLE. In the early 2000s, with the renewed interest in Kurenniemi's work, DIMI-6000 was given to the University of Helsinki Electronic Music Studio, where most of Kurenniemi's other remaining instruments are stored. The instrument was on display at the Kurenniemi exhibition in the Kiasma Museum of Contemporary Art in Helsinki from November 2013 through February 2014.

Despite some efforts to revive the instrument, the DIMI-6000 is currently in a non-operational state. Its system software cassettes are either lost or destroyed. All hardware components and most of its documentation are, however, still present.

6. CONCLUSIONS

Kurenniemi's impulsive working style is reflected in the DIMI-6000. In particular, he was eager to use the first available microprocessor, which proved to be too slow for the instrument to be used as a serious compositional tool or integrated music production device. Further, the bankruptcy of Digelius Electronics in 1976 prevented the development of a next-generation instrument.

Like Kurenniemi's designs in general, the DIMI-6000 had two typical characteristics: the application of digital electronics and an unconventional user interface. The lack of a piano-style keyboard and the steep learning curve deterred many composers from using the instrument. Furthermore, due to its technical shortcomings, especially the limited processing power of the C8008 microprocessor, the DIMI-6000 saw only limited use even by composers interested in computer programming.

However, in its time, DIMI-6000 was a significant technical achievement. For a short period in the mid-1970s, it placed the YLE studio at the forefront of electronic music technology.

Acknowledgments

The authors wish to thank Messrs Jukka Ruohomäki and Pekka Sirén for interviews and invaluable help as well as Messrs James Andean, Daniel Araya and Ralph Lundsten for valuable comments.

7. REFERENCES

[1] M. Ojanen, J. Suominen, T. Kallio, and K. Lassfolk, "Design Principles and User Interfaces of Erkki Kurenniemi's Electronic Musical Instruments of the 1960's and 1970's," *Proceedings of the 7th international conference on New interfaces for musical expression: NIME 2007,* pp. 88-93, 2007.

[2] H.F. Olson, *Music, Physics and Engineering,* 2nd ed, Dover, New York, pp. 415-426, 1967.

[3] Interview of Erkki Kurenniemi by M. Ojanen and J. Suominen, Musicology, University of Helsinki, May 29, 2004.

[4] Sirén, Pekka 1976. "Kokeellisesta toiminnasta YLE:ssä," *Tehosteet ja ääni-ilmaisu.* Ed. Reino Korppio. Helsinki: Yleisradio. pp. 49-58, 1967.

[5] Interview of Pekka Sirén by K. Lassfolk, Musicology, University of Helsinki, March 20, 2014.

[6] J. Ruohomäki. *DISMAL-ohjelmiston käyttöohjeet.* Helsinki, YLE, 1977.

[7] E. Kurenniemi, "Dimi Family," Seminar lecture in UNESCO congress of electronic music. FIMIC El.mus DAT 148, 1978.

[8] B. Santo, "25 microchips that shock the world." *IEEE Spectrum*, Volume 46, Issue 5, May 2009, pp. 34-43.

[9] R. Laine and L. Kotilainen. *Jänniteohjattu äänisyntesoija. Kootut Kytkennät I.* Helsinki: Kustannus Oy Infopress. pp. 58-65, 1978.

[10] Telephone interview of Jukka Ruohomäki by K. Lassfolk, Oulu/Espoo, March 31, 2014.